VALUING CHANGES IN MORBIDITY: WTP VERSUS COI MEASURE[1]

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1.0 INTRODUCTION

This paper uses economic theory to examine behavior to mitigate adverse health effects and to compare cost of illness (COI) and willingness to pay (WTP) measures of damages. It also provides estimates of conceptually correct WTP economic benefit measures for changes in asthma severity. These WTP measures are compared to COI measures, variations of which are frequently used to value changes in adverse health symptoms. Consistency checks on these WTP estimates, obtained through a contingent valuation bidding approach, are developed and discussed.

While much research has focused upon valuing changes in mortality, limited empirical work has been completed for valuing changes in morbidity (Chestnut and Violette, 1984). Morbidity is, however, among the major concerns in setting many health, safety and environmental control regulations. The Clean Air Act of 1977 is one such example where standards are to be set to protect the health of sensitive populations. In most instances, the health impacts of concern relate to morbidity rather than mortality.

Among the most frequently used approaches to valuing changes in morbidity has been the COI approach following or modifying the original work of Rice (1966). Reviews of this approach and applications can be found in Hu and Sandifer (1981), Institute of Medicine (1981), and Chestnut and Violette (1984). Recent prominent applications include Rice and Cooper (1976), Manuel et al. (1983), and Hartunian et al. (1981).

The general COI approach to valuing changes in illness from changes in a policy or standard, is to obtain epidemiological estimates of the changes in the expected level of illness and then to estimate a change in work loss and medical related expenditures due to the change in illness. Typically, COI estimates are made for the existing level of illness, then a X% change in illness is predicted to result in an X% change in COI.

COI approaches are frequently used due to the relative availability of data to conduct the analysis, but they have serious limitations including:

1. The epidemiology estimates upon which they are based have not typically accounted for mitigating behavior. For example, if air pollution increases, individuals may change their activity patterns or other expenditures in order to reduce their exposure or to mitigate the adverse health effects. This may cause epidemiology estimates to show fewer changes in health effects than would otherwise have occurred. The costs of these behavioral and expenditure changes are not incorporated in COI estimates.

2. COI estimates typically are not able to incorporate values for the effect of illness upon one's lifestyle or discomfort.

3. Often insufficient data exist for a complete COI estimate.

The focus in this paper is on the importance of the first two limitations. Section 2.0 presents an economic model of behavior that describes incentives to undertake mitigating behavior and breaks down WTP into individual damage components, which provides a theoretical comparison between WTP and COI measures. Section 3.0 briefly discusses the surveys used to provide an application of the analysis and presents selected results. Because these estimates are generated through a contingent valuation (CV) approach, they may be subject to hypothetical inaccuracy (Cummings et al., 1984; Rowe and Chestnut, 1983). Therefore, a consistency check procedure was developed and implemented.

In summary, the analysis finds that WTP measures for changes in asthma are on the order of 1.5 to 3 times estimated COI. The consistency checks demonstrate that the 79 percent of the CV WTP bids were likely to be accurate for the purposes of the analysis.

2.0 AN ECONOMIC MODEL OF VALUE AND MITIGATING BEHAVIOR

A health production function model is developed based upon the models by Harrington and Portney (1982) and Gerking et al. (1983) and is used to illustrate the level of defensive expenditures and activities the individual will choose to undertake, how epidemiological analyses can be affected when defensive expenditures are ignored, and the components of WTP and, therefore, how WTP and COI measures theoretically compare.

2.1 MODEL SUMMARY

For those who wish to skip the mathematical model, we first present a summary of its implications. They include:

1. The model uses many simplifying assumptions, not all of which are easily accepted. Generalizations of the model (discussed in Rowe and Chestnut, 1984) greatly add to complexity, but do not change the basic conclusions outlined below.

2. Individuals will engage in defensive efforts to minimize adverse health effects to the point where marginal benefits equal the marginal costs in time and money for defensive efforts. The benefits of defensive efforts include improvement in utility (well-being); medical costs no longer incurred, and the opportunity cost of time no longer spent sick. The amount of defensive efforts undertaken depends upon the effectiveness of these efforts and their associated costs.

3. An individual's WTP to reduce risks of adverse health effects associated with exposures to air pollution is expected to include values related to the following damage categories:

   i. Medical expenditures for treatment of illness.

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ii. Disutility associated with foregone income due to time off from work, lower wages or lower productivity at work due to illness.

iii. Disutility of loss of ability to participate in desired leisure activities, household chores, child care and other activities.

iv. Disutility of discomfort due to illness.

v. Disutility of mitigating behavior to prevent illness (preventive health care expenditures, inconvenience of activity changes, including when and where to work, recreate and live, etc.).

4. COI estimates, based upon medical costs and workloss (categories 1 and 2) for health incidents measured by epiemiological studies, will understate WTP to reduce health impacts by missing the value of defensive behavior taken to reduce adverse health incidents and by ignoring the discomfort and change in lifestyle incurred as a result of adverse health incidents.

2.2 THE MODEL

The basic premise of the health production function models, as applied to health analyses, is that the individual can be expected to take action to protect or enhance his or her health (Grossman, 1972). People do not necessarily accept the effects of pollution passively, but may respond with action that will mitigate the health effects that otherwise would have occurred.

The individual's well-being, or utility, is assumed to be a function of the goods and services consumed and his or her state of health. The direct effects of the individual's state of health on utility would include pain and discomfort experienced during an illness.

$$U = U(X,H) \tag{2.1}$$

Where:

U = the individual's utility in a given time period

X = goods, services and leisure activities the individual consumes that are unrelated to his or her health, $U_X > 0$

H = the individual's state of health, $U_H > 0$

The individual's state of health (H) is a function of defensive expenditures and health enhancing activities undertaken, including such things as preventive medical care, exercise, and diet; exogenously determined levels of pollution; and biological, social and economic characteristics of the individual, such as congenital conditions, age and education, that influence the effectiveness with which he or she can maintain a given state of health. The level of defensive expenditures is chosen by the individual and is a function of pollution and social and economic characteristics of the individual. A simplifying assumption used here is that defensive expenditures and activities affect utility only through their effect on health. In reality many of these activities and expenditures jointly produce utility in other ways as well, such as the enjoyment of tennis or swimming produced jointly with the health benefit.

$$H = H(D,P,Z) \quad (2.2)$$

Where:

D = defensive expenditures and activities, $H_D > 0$
P = pollution, $H_P > 0$
Z = biological, social and economic characteristics of the individual, $H_Z > 0$

Time spent sick and medical expenditures made in response to illness enter into the individual's budget constraint because they affect the amount of time and money the individual has for other goods, services and activities, but they do not directly enter the individual's utility function. These medical expenditures do not prevent additional illness, but may mitigate the discomfort and activity interference of illness that occurs.

$$Ts = Ts(H) \quad (2.3)$$

$$M = M(Ts) \quad (2.4)$$

Where:

Ts = time spent sick, $Ts_H > 0$
M = medical expenditures in response to illness, $M_{Ts} > 0$

The individual faces the following time and budget constraints.

$$X*Px + D*Pd + M*Pm = w*Tw + I \quad (2.5)$$

$$X*Tx + D*Td + M*Tm + Ts + Tw = T \quad (2.6)$$

Where:

Pi = price per unit of i, for i=x, d, and m
Ti = time per unit of i, for i=x, d, and m
Tw = time spent working
w = the individual's wage rate
I = nonwage income
T = total time available

Equations 2.5 and 2.6 can be combined into a "full income" constraint by assuming that all time is valued at the wage rate and defining a combined dollar and time cost: Qi = Pi + w*Ti. Using w as the value for all time assumes that individuals choose to work to the point where the marginal benefits of working (the wage earned) just equal the marginal costs in terms of the value of time lost from other activities. (This is a simplifying assumption that could be relaxed in a more complex model.) The full income constraint is:

$$X*Qx + D*Qd + M*Qm + w*Ts = w*T + I \quad (2.7)$$

Substituting with Equations 2.2, 2.3 and 2.4, the Lagrangian is:

$$L = U(X, H(D, P, Z)) - \lambda(X*Qx + D*Qd + M(Ts(H(D, P, Z)))*Qm + w*Ts(H(D, P, Z)) - w*T - I) \quad (2.8)$$

The first order conditions are as follows with subscripts denoting partial derivatives.

$$\frac{\partial L}{\partial X} = U_X - \lambda Q_X = 0 \tag{2.9}$$

$$\frac{\partial L}{\partial D} = U_H {*} H_D - \lambda \left(Qd + M_{Ts} {*} Ts_H {*} H_D {*} Qm + w {*} Ts_H {*} H_D\right) = 0 \tag{2.10}$$

$$\frac{\partial L}{\partial \lambda} = w{*}T + I - X{*}Qx - D{*}Qd - M\left(Ts(H(D,P,Z))\right) {*} Qm - w{*}Ts\left(H(D,P,Z)\right) = 0 \tag{2.11}$$

The first order condition for defensive activities and expenditures (Equation 2.10) indicates that the utility maximizing individual will engage in defensive efforts to the point where the marginal benefit equals the marginal cost. In this case the marginal benefit is the dollar value of the improvement in utility obtained with an additional unit of defensive efforts ($U_H{*}H_D/\lambda$) plus the medical expenditures that no longer have to be incurred as a result of a unit increase in defensive efforts ($M_{Ts}{*}Ts_H{*}H_D{*}Qm$), plus the opportunity cost of time no longer spent sick as a result of a unit increase in defensive efforts ($w{*}Ts_H{*}H_D$). The marginal cost is the unit cost of defensive efforts including both money and time (Qd). This means that the amount of defensive efforts undertaken will depend on the effectiveness of these efforts in maintaining health and on the costs and discomfort associated with time spent sick, as well as on the direct costs of the defensive efforts.

Willingness to pay for changes in pollution can be defined with the indirect utility function. Willingness to pay is the change in income that would hold utility constant when pollution changes. The indirect utility function is:

$$V = V(I, P, w, Qd, Qm, Qx) \tag{2.12}$$

One way to express willingness to pay for changes in pollution is to assume that the wage rate and other prices do not vary with pollution and to ask how income has to change in order to keep V constant as P changes. This defines an income compensated demand curve for P and the derivative of this function with respect to P gives the marginal willingess to pay for P. This demand curve can be denoted as $I'(P)$ and it is defined such that

$$V(I', P) = V_0 \tag{2.13}$$

where V_0 is some fixed level of V and wages and other prices are constant. The total derivative of (2.13) is equal to 0 since V_0 is a constant. Therefore, the total derivative of V with respect to P is:

$$\frac{dV}{dP} = V_I {*} \frac{dI'(P)}{dP} + V_P = 0 \tag{2.14}$$

This can be written as:

$$\frac{dI'(P)}{dP} = -\frac{V_P}{V_I} \qquad (2.15)$$

which says that the change in I that would hold V constant when P changes is equal to the negative of the ratio of the marginal utility of P to the marginal utility of I. This is an expression for willingness to pay for marginal changes in pollution.

Another expression for willingness to pay for changes in pollution can be obtained by substituting from the first order condition for defensive efforts into V_P and V_I.

$$V_P = U_H{*}H_P - {*}M_{Ts}{*}Ts_H{*}H_P{*}Qm - {*}Ts_H{*}H_P{*}w \qquad (2.16)$$

$$V_I = \lambda \qquad (2.17)$$

Substituting for U_H from Equation (2.10) and simplifying:

$$-\frac{V_P}{V_I} = -\frac{H_P}{H_D} * Qd \qquad (2.18)$$

This says that willingness to pay for a marginal change in pollution is equal to the costs of defensive efforts (D) that would (or would no longer) be needed to maintain health at a given level. Notice that, given the assumptions of the model, this expression for willingness to pay is the same regardless of the associated direct utility effects, changes in medical expenditures or changes in time spent sick. This would no longer be accurate if the first order condition for defensive efforts did not hold or if the assumption that the only effect of D on utility is through H were not correct.

Harrington and Portney (1982) point out that cross sectional epidemiological studies that estimate a dose response relationship between health and pollution exposures without considering defensive behavior, will be estimating the total derivative of H(D, P, Z) with respect to pollution rather than the partial derivative. The total derivative of H with respect to P is:

$$\frac{dH}{dP} = H_D * \frac{dD}{dP} + H_P \qquad (2.19)$$

For an increase in P, the first term can be expected to be positive (indicating an increase in health) while the second term can be expected to be negative (indicating a decrease in health). The observed effect of pollution on health is therefore less than what would occur without defensive efforts (i.e., if the first term were zero) and the benefits of preventing or reducing pollution are understated if defensive efforts are ignored.

Medical expenditures and time lost from work due to illness comprise the typical "cost of illness" estimate for changes in pollution. These costs are related to the total change in health that occurs as a result of a change in pollution. Therefore a cost of illness estimate for changes in pollution can be expressed in terms of the model as:

$$\frac{dC}{dP} = w * Ts_H * \frac{dH}{dP} + Qm * M_{Ts} * Ts_H * \frac{dH}{dP} \qquad (2.20)$$

Where:

C = the cost of illness

Note that the first term on the right hand side uses the wage rate as the opportunity cost of all time spent sick. This is an overstatement of what is usually included in cost of illness estimates, since these typically include only time lost from work. A typical cost of illness estimate can therefore be expected to be less than or equal to Equation 2.20.

The following discussion parallels the presentation of Harrington and Portney (1982) and examines the relationship between this expression for cost of illness and willingness to pay for changes in pollution.

From Equation (2.10) we know that:

$$\frac{U_H}{\lambda} - \frac{Qd}{H_D} = M_{Ts} * Ts_H * Qm + w * Ts_H \tag{2.21}$$

Therefore:

$$\frac{dC}{dP} = \frac{U_H}{\lambda} - \frac{Qd}{H_D} \frac{dH}{dP} \tag{2.22}$$

Substituting from (2.19) and solving for the expression derived for willingness to pay for changes in pollution in (2.18):

$$WTP = -\frac{H_P}{H_D} * Qd = \frac{dC}{dP} + \frac{dD}{dP} * Qd - \frac{U_H}{\lambda} * \frac{dH}{dP} \tag{2.23}$$

On the basis of equation 2.23, willingness to pay for changes in pollution can be expected to exceed cost of illness because the second and third terms can be expected to increase WTP. The second term is the change in defensive expenditures associated with a change in pollution, and the third term is the dollar equivalent of the direct change in utility (i.e., the pain and discomfort) associated with the change in pollution. For example, an increase in pollution can be expected to cause the individual to increase defensive expenditures and to have a negative effect on the individual's utility due to the discomfort of increased illness.

3.0 SURVEY DESIGN AND RESULTS

3.1 THE SURVEYS

The applied research was designed to supplement research underway at the UCLA School of Medicine (Gong et al. 1984) concerning the effects of air pollution on people with asthma. Three sets of survey instruments were used: The epidemiology instruments on asthma severity, respiratory status, medicine use and behavioral data; the economic survey daily diary of perceptions and activities; and the economic survey general questionnaire on background activities and WTP.

The Epidemiology Analysis

UCLA researchers collected data for over 90 subjects with diagnosed asthma over an eleven month period from January 1983 through November 1983. All of the subjects lived throughout the study period in Glendora, California, a town in the San Gabriel Valley east of Los Angeles where state and federal standards for ambient ozone and other pollutants are frequently exceeded. During the study period, each subject kept a daily record of his or her asthma symptoms. These were measured in three different ways: 1) Subjects rated their daytime and nighttime symptoms in several categories on a 1 to 7 severity scale; 2) Subjects took twice daily readings of their pulmonary peak flow; and 3) Subjects used, as needed, an inhaler that recorded the amount of medication used. Every two weeks the subjects were given more extensive tests and answered questions about any illnesses they may have had or other things that may have affected their asthma during the two week period. Air pollution levels were taken from the South Coast Air Quality Management District station #60. Weather conditions and the amount of pollens, fungal spores, and potential aeroallergens were also measured at the on-site facility. See Gong et al. (1984) for additional details.

The Economic Surveys

The economic study was designed to obtain additional information from the UCLA panel without interfering with the UCLA study. Subjects age 16 and over (the adult group) were asked to complete the daily diary at home each day for four weeks and to complete the general questionnaire during their last visit to the UCLA facility. The parents of subjects under 16 years old were asked to complete the general questionnaire only. Sixty-four of the then current 65 adults and all eighteen parents of the panelists under 16 agreed to participate.

The Daily Diary. The purpose of the diary was to supplement the information gathered by UCLA concerning daily asthma symptoms with data about how the subject may have changed his or her activities in response to or in anticipation of worse than normal asthma symptoms. There were several questions addressed through the diary including:

- Do individuals perceive air pollution as affecting their asthma and do their perceptions about air pollution accurately correlate with ambient conditions?

- When individuals anticipate having a bad day due to air pollution, do they alter their behavior to reduce or minimize the effects? This defensive behavior affects epidemiologic estimates and represents a change in well-being often ignored in analyses of morbidity effects.

The General Questionnaire. The purpose of the general questionnaire was to identify ways in which asthma affects people's well-being, and to estimate economic measures of changes in well-being associated with changes in the frequency of asthma symptoms. One goal was to compare COI estimates to WTP estimates. The questionnaire consisted of seven sections. The first six addressed asthma effects on medical expenditures, work and school, leisure, chores and residential choice. Part VII of the questionnaire asked the respondents to rank in importance the categories of benefits they might receive if their asthma improved. These categories followed from the questions in the previous sections and included lower medical expenditures, higher wages or productivity, more flexibility about where to live, better chance to participate in leisure activities, and less pain and suffering or discomfort. After the ranking, repondents were asked how much they would be willing to pay in additional taxes each year for a program that would reduce their bad asthma days by one-half. Evaluation of zero bids, the medical cost data and ranking questions were used to analyze the internal consistency of an individual's WTP responses. The final question was household income. Other socioeconomic variables were available through the UCLA questionnaires.

3.2 DAILY DIARY RESULTS

The diary results are not the focus of this paper, but a summary of preliminary results (reported in detail in Rowe et al., 1984, and Rowe and Chestnut, 1984), serves to illustrate the potential importance of mitigating behavior in epidemiology and COI studies.

Each of 64 adult respondents completed the diary for an average 27.8 days resulting in a total of 1779 observations (or person-days). Individuals started completing the diary anywhere between October 12 and November 2, 1983 depending upon their schedule of visits to the UCLA Glendora facility. Due to being in the fall of the year and the unusual amount of rain, there were only 13 days with peak hourly ozone readings in excess of 12 pphm (the federal standard) in the Glendora area during the study period, although peak hourly readings above 30 pphm are not uncommon in the summer and early fall in this area.

In summary, the diary result showed:

1. Asthmatics revealed accurate perceptions concerning changes in air pollution levels.

2. On days when the peak hourly ozone level was at the standard of 12 pphm, 20 percent of the sample felt air pollution might adversely affect their asthma that day.

3. When asthmatics believed air pollution might adversely affect their asthma, they were twice as likely to expect a bad asthma day in terms of undesirable asthma symptoms.

4. When asthmatics felt air pollution may or did lead to a bad asthma day, as compared to days when they neither expected a bad day nor expected air pollution to adversely affect their asthma, they reduced their chores by 14 to 18 percent, reduced their active leisure and inactive indoor leisure by 13 to 17 percent, experienced .56 hours more work loss, and spent in excess of 25 percent more time in inactive outdoor leisure, nonleisure and sick.

3.3 GENERAL QUESTIONNAIRE RESULTS

Medical Expenditures

Expenditure data were collected on medical supplies, equipment and special treatment programs. These data were separated into fixed and variable costs and adjusted by the number of asthmatics in the household. Information on doctor and hospital visits was obtained from the respondents and from the UCLA data files.[2] Sample averages are reported in Table 1.

Table 1
Average Costs per Year for 82 Asthmatics in Glendora, California

	Household Total	For This Asthmatic
Total Fixed Cost Expenses	$713	$573
Total Variable Expenses/Year.	528	435
Household Paid Fixed Cost Expenses	619	486
Household Paid Variable Cost Expenses/Year	268	208
Insurance Paid Fixed Cost Expenses	94	87
Insurance Paid Variable Cost Expenses/Year	260	227

Fixed cost expenses refer to one-time goods such as Intermittent Positive Pressure Breathing Machines.

Variable costs refer to expenses repeatedly incurred such as for medicines or doctors visits.

Insurance includes government programs.

Table 2
Variable Medical Costs as a Function of Asthma Severity

Dependent Variable: variable medical costs paid by the household (MEDVHH):

Explanatory Variable	Coefficient	t-ratio
Constant	-1.13	-.49
Log (SEV)	.92	2.4
Log (INC)	-.105	-.47
Log (RTFM)	.45	1.06
ADULT	-.51	-1.33
SEX	.90	2.86
F	4.73	
R^2	.24	
NOBS	82	

Sample: Full General Questionnaire Sample
Logs in base e.
See Table 3 for variable definitions.

Estimated variable medical costs paid by the household and attributed to the respondent, including medications, treatments, doctors and hospitals, were regressed against asthma severity (SEV) and selected socioeconomic variables (Table 2). Significant in the regression results is that the elasticity of variable medical costs with respect to severity is just less than one, indicating that variable costs increase just less than proportionally to severity. A variable for whether or not the respondent had insurance was never significant when included and had minimal effect on the other coefficients.

Work and School

Seven adult respondents felt their asthma affected their job status in terms of whether they were employed full-time or not (three were employed part-time and four not at all). These individuals ranked asthma effects on work significantly more important than did the remainder of the sample. (See ranking discussion below). Of the 47 respondents employed full or part-time, 20 felt their choice of job was affected by their asthma, with most taking a less stressful job so as not to aggravate their asthma. Twelve respondents felt their asthma affected their income. Including the four respondents unemployed due to asthma, income was affected for 25 percent of the population. These respondents had higher asthma severity than the rest of the sample. In summary, more severe asthma is likely to affect short term and long term earning potential.

Turning to students, nearly two of every three felt their asthma affected their performance in school, particularly their extracurricular activities (63 percent of all students) and their grades (40 percent of all students).

Non-Paid Chores and Leisure

Eighty percent of the adult asthmatics felt that their asthma affected their ability to perform chores that they routinely do, but do not get paid for. Nineteen percent (10 respondents) hired individuals on a regular basis to perform chores, which they would not do if their asthma were less severe. These individuals spent an average $1,478 per year for these services. These individuals also had significantly higher average severity relative to the remainder of the sample. A simple log linear relationship between the dollar costs of chores hired and severity for these individuals finds a statistically significant elasticity of .88, i.e., a 10 percent increase in severity results in a 8.8 percent increase in the costs of chores hired out in part due to asthma. These individuals also later ranked reducing activity affects from reducing asthma to be much more important than for the remainder of the sample (See rankings below).

Asthma affects leisure activities for nearly 75 percent of the respondents. The respondents indicated that most often they change their activities or spend less time in leisure activities while occasionally doing the same activities at a different time of day.

Rankings

Respondents were asked to rank, in descending order of importance, five benefits they might receive from reduced asthma. The ranking and CV portion of the questionnaires are included as an appendix. The ranking question was a final step in preparing respondents for the total willingness to pay question and, in combination with estimated medical costs, provides a validation check on the WTP responses. The ranking responses are summarized in Table 4a. Assigning a cardinal value system of one when, a category is

Table 3

Definition of Variables

Name	Definition	Source
SEV	Severity of asthma based upon respondents reported monthly Frequency times Intensity (Reported on UCLA instruments) summed over the calendar year	UCLA
INC	Income	General
AGE	Age	UCLA
SEX	Sex; 0 = male, 1 = female	UCLA
MEDVHH	Variable medical costs/year paid by the household for this asthmatic (Doctors, hospitals, medicines, etc.)	General
RTFM	Respondent's share of total household asthma (0-100%)	General
GDAY	Highest day rating on UCLA scale still considered to be a good asthma day	Diary and General
NBAD	Number of bad days/year - number of days where the daily asthma rating is greater (worse) than GDAY	UCLA
NBADR	1/2 NBAD = Number of days reduced in WTP scenarios	--
ADULT	Is the respondent on adult (16+ years) yes= 1, no = 0	General
TAXBID	WTP response to reduce bad asthma days in half through a tax vehicle	General
NOBS	Number of observations used in the analysis	--

UCLA = UCLA Survey Instruments
Diary = Economic Survey Daily Diary Instrument
General = Economic General Questionnaire

Table 4
Results of the Ranking

a. Rankings

Overall Category	Mean Rank	SE of the Score	# times Ranked: Mean*	1st	2nd	3rd	4th	5th	# times not Ranked (= 6)
Discomfort	1	2.16	.16	40	19	11	1	4	7
Activities Effects	2	2.89	.18	22	20	12	13	3	12
Medical costs	3 tie	3.63	.20	12	14	19	8	5	24
Work Loss	3 tie	3.79	.20	7	20	14	11	2	28
Residential Choice	5	4.88	.15	1	6	9	10	16	40

b. t-ratios on pairwise comparisons of Average Scores**

	Discomfort	Activities	Med. Costs	Work Loss
Discomfort	--			
Activities	3.0	--		
Medical Costs	5.7	2.7	--	
Work Loss	6.4	4.5	.6	--
Residential Choice	12.4	8.5	5.0	4.4

ranked first and five when a category is ranked fifth, and six if the category is not ranked, yields the overall mean ranking.

Part (b) of Table 4 presents t-test results for the hypothesis that the mean scores are identical. The t-tests reject the hypothesis that the mean scores are identical except for medical costs and work loss. Discomfort and asthma effects on leisure and recreation activities were clearly ranked above medical costs and work loss, which were ranked very closely to each other. Medical costs and work loss represent the effects of illness that are typically reflected in cost of illness measures. The low ranking for residential flexibility should be cautiously interpreted because it is based upon the responses of a group of asthmatics who live in a very high air pollution area. They have not moved in order to reduce their exposure to air pollution, which may aggravate their asthma, and they may not be representative of other asthmatics in this regard.

The ranking results were also analyzed using an ordinal value system giving the probability that one category was ranked higher than another. The results substantiate those in Table 4b, but are statistically somewhat less significant. Discomfort is still statistically significantly ranked above all other alternatives.

Logit regression analyses examining whether an individual would rank one category as more important than another (all combinations were examined) as a function of asthma severity and other socioeconomic variables were generally statistically insignificant. Similarly, linear discriminant functions (Klecka, 1980) predicting which of the five categories would be ranked first were statistically insigificant. However, a linear discriminant analysis examining whether an individual ranked a lifestyle (discomfort or leisure effects) or COI (medical costs, work loss) category first showed promise and is reported in Table 5. Approximately sixty percent of the individual observations could be classified using this approach. As age, family size and number of bad asthma days increase, asthmatics were more likely to rank a COI damage first; while as increases in income, being an adult (versus child), and increases in the respondent's share of total household asthma lead to increased likelihood of ranking a lifestyle category first.

Tax Bid Analysis

The following contingent valuation question was asked: "If federal, state or local governments set up programs that could reduce pollens, dusts, air pollutants, and other factors throughout this area that might reduce your (and your household's) bad asthma days by half, but would cost you increased tax dollars, what would be the maximum increase in taxes each year that you and your household would be willing to pay and still support such a program?"

A payment card with alternative dollar amounts accompanied the question. The question appeared generally to be well received with 68 non-zero responses, 13 zero responses and one refusal. Upon evaluation of the responses, some zero observations were retained and a few non-zero bids deleted resulting in a mean bid for 65 observations of $401 per year with a standard error of the mean of $85. The mean estimated variable medical costs paid by the household for this group of respondents was $272.00 with a standard error of the mean equal to $27.62. The average number of bad asthma days was 38 per year.

A model relating the tax bid to the number of bad asthma days reduced (1/2 the number of bad days = NBADR) and the level of intensity at which the respondent differentiated between a good and bad asthma day, GDAY, is reported in Table 6. The sample is discussed below. The model suggests that WTP increases at about one-half the rate of the

Table 5

Standardized Discriminant Function Coefficients and Classification Results on Ranking Data

I. Cannonical Discriminant Function between Group 1 and Group 2 (see Section II for definitions)

Variable	Coefficient [1]
ADULT	-.40
FAMILY SIZE	.70
RTFM	-.51
INCOME	-.01
AGE	.66
NBAD[2]	.47

II. Predicted Group Membership

Group 1 Individuals who ranked a cost of illness category first (medical costs, work loss)

Group 2 Individuals who ranked a quality of life category first (discomfort, reduced activities)

	Group 1	Group 2
Actual number of observations	19	62
Predicted number in Group 1	13 (68.4%)	26 (41.9%)
Predicted number in Group 2	6 (31.6%)	36 (58.1%)
Overall Prediction Power	60.5% of individuals were correctly classified.	

[1] No statistical significance is assigned to individual coefficients. A (+) sign indicates increased probability of ranking a group 1 category first, a (-) sign indicates increased probability of ranking a Group 2 category first.

[2] Results with SEV instead of NBAD are similar but the overall percent of correct classification is reduced to 58 percent.

Table 6

Tax Bid Regression and Predicted WTP Values for a 50 Percent Reduction in Bad Asthma Days

a. Regression Model

Dependent Variable Log (Tax Bid)

Explanatory Variable	Coefficients	t-ratio
Constant	.2834	.078
Log (NBADR)	.565	4.25
Log (GDAY)	.973	1.43
Log (MEDVHH)	-.0433	-.280
Log (INC)	.292	.896
SEX	-.416	-.899
N OBS	65	
F	5.276	
R^2	.3090	

b. Predicted WTP Values ($'s)

	No. of Bad Days Reduced			
GDAY	1	5	15	50
1 (no symptoms)	$22	$54	$101	$199
2 (very mild symptoms)	43	106	198	391
3 (mild symptoms)	64	158	294	580
4 (moderate symptoms)	84	209	389	767

Logs in base e

Variable names defined in Table 3

Predicted WTP values calculated for males at the sample means for income and variable medical costs.

number of bad days reduced and increases almost linearly with the defined level of intensity of what was viewed by respondents as a good or bad asthma day. The low statistical significance on the Log (GDAY) coefficient may reflect the fact that a linear index was used to define GDAY; although the growth in the intensity of effects from "no symptoms" to "moderate symptoms", may be non-linear, and could in alternative specifications be respecified as four zero-one variables.

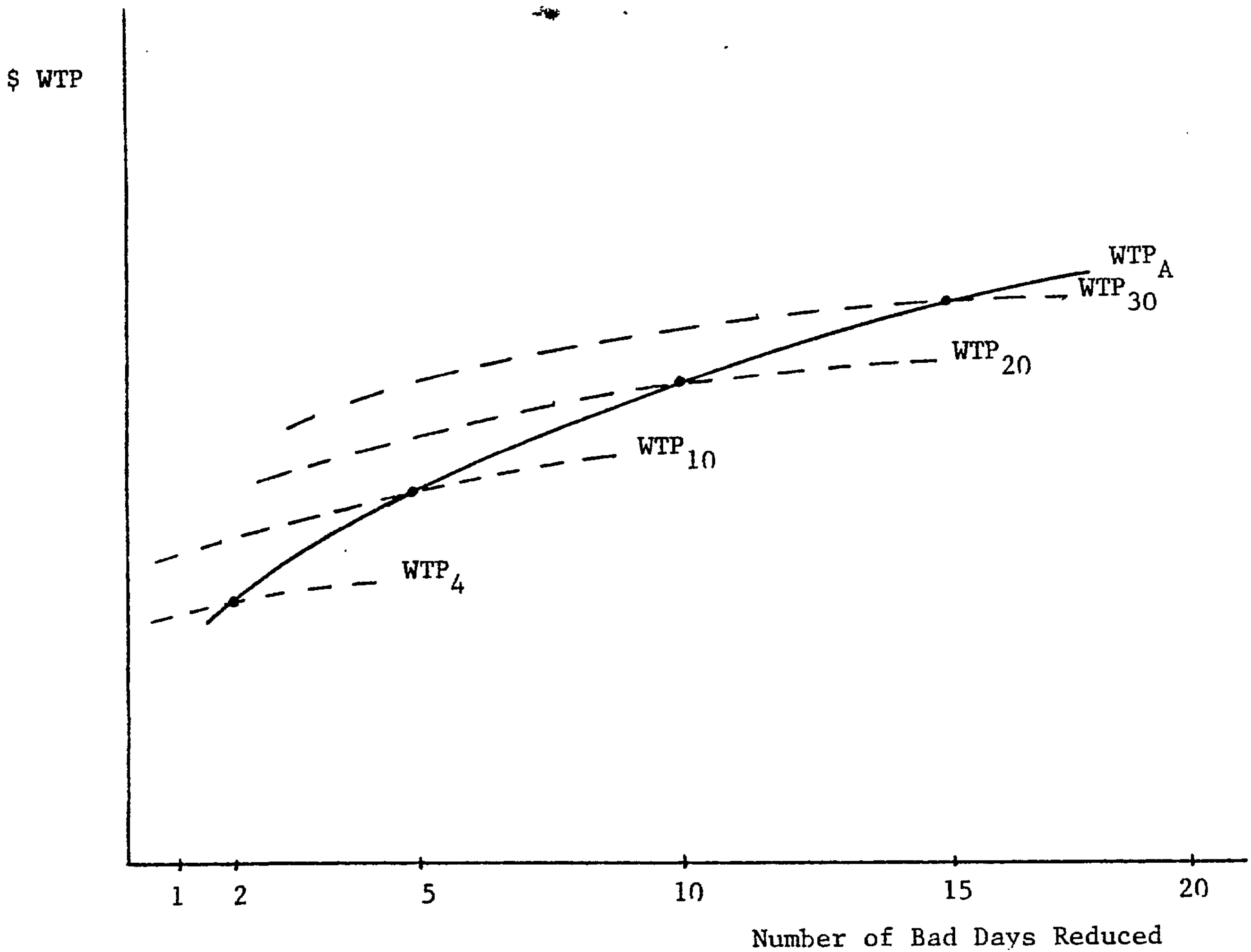
Care must be taken in interpreting the tax bid regression model results. The regression estimates a WTP curve for a 50 percent reduction in bad asthma days estimated across individuals with different asthma severity (or different levels of bad asthma days). As a result, the regression curve does not trace out an individual WTP curve, but a locus of points representing the WTP to reduce asthma in half for each NBAD level. For example, it traces out the WTP to reduce five bad days for individuals with ten total bad days, WTP to reduce ten bad days for individuals with twenty total bad days, and so forth. The WTP value to reduce five bad days, however, may be different for those individuals with ten or twenty total bad days. If WTP by an individual increases at a decreasing rate with the number of bad days reduced (i.e., with an increase in good days) and the WTP to reduce X bad days is the same for all individuals, regardless of the baseline total number of bad asthma days experienced, then the underlying WTP curves of different individuals all fall on the regression function. More likely, WTP to reduce X bad days (i.e., improve by X good days) increases with the baseline number of bad days experienced and the underlying individual WTP curves are flatter than the regression line as illustrated in Figure 1. It is important to note, however, that the shape of the underlying WTP curves cannot be determined from this data.

A major issue in contingent valuation (CV) studies has been the credibility of the values received through hypothetical questions (Cummings et al., 1984). This survey instrument was designed to specifically examine the plausibility of the CV responses by examining zero and large bids and by comparing the tax bid, medical costs, rankings and other responses. Of the 82 respondents, one refused to respond to the tax bid question and one gave a bid exceeding his stated income. These responses were deleted. Twelve zero responses were given. Based upon a typical zero bid follow-up question (see the Appendix) eleven bids would have been deleted, but subsequent analysis indicated that five of these bids were probably valid because the individual's asthma condition was such that he or she had zero or one bad day in the last year and very low medical costs. Therefore, reducing bad asthma days by half could appropriately be valued at zero. The remaining seven zero bids were by respondents with at least $150 per year in variable medical costs, nine bad asthma days and who gave a rejection response to the zero bid follow-up questions. These were deleted from further analysis. Four non-zero bids were also deleted because for those individuals NBAD equalled zero, while the bid exceeded $100 per year, indicating that the bid must be for something other than to reduce the number of bad asthma days.

All 68 remaining WTP responses were analyzed with the following consistency check. It was first assumed that a 50 percent reduction in bad asthma days would yield a 46 percent reduction in variable medical costs (.92 from Table 1 times 50 percent). WTP should therefore exceed .46 of the individual's variable medical costs. Further, if changes in medical costs are ranked third, for example, total WTP should exceed .46 of variable medical costs by at least a factor of three, if changes in each of the above ranked categories are valued at or more highly than changes in medical costs. If changes in medical costs are ranked fifth then total WTP should exceed .46 of variable medical costs by a factor of five or more and so forth.

Figure 1

Potential Relationship Between the Estimated WTP Function and the Underlying Individual WTP Functions



WTP_A = Estimated WTP function across respondents for a 50 percent reduction in NBAD

WTP_i = WTP function for an individual with NBAD = i

NBAD = Number of bad asthma days.

There are at least two important limitations to the consistency check analysis. First, while the individual may be attempting to give accurate and reasonable estimates for their medical costs and underlying values for changes in asthma, measurement error may result in failure of the consistency check. The second limitation is discussed below.

Of the 68 individuals with responses analyzed with the consistency check, 37 provided medical cost, tax bids and rankings that were consistent with the above assumptions, and another 16 were consistent using a reduction in medical costs of 25 percent or allowing a 33 percent measurement error in either the tax bid or medical cost estimates.

This brings up the second limitation in the consistency check. The WTP bids are based upon a 50 percent change in bad asthma days, while the estimated reduction in medical costs are based upon a 50 percent change in severity measured as the sum of monthly frequency times the intensity of asthma symptoms. For an individual with a large number of bad asthma days, a 50 percent reduction in bad asthma days and in overall asthma severity may be quite similar. The correlation between 50 percent changes in these measures is likely to lessen as the number of bad asthma days decreases. For this reason, the alternative of 25 percent of medical costs was used in the second application of the consistency check.[3] We view this as a weakness in our application, rather than the general design, of the consistency check procedure. Overall, 78 percent of the WTP responses (including zero bids) could be evaluated as "probably reasonable."

Of the fifteen non-zero WTP responses that did not pass either application of the consistency check or were viewed as of "uncertain quality," four observations were discarded as likely to be "unreasonable."[4]

In summary, the use of consistency checks based upon other data generated in the questionnaires is a promising approach in CV instruments to determine "reasonable" and "unreasonable" responses. They also help to illustrate in an application such as this where the valuation issue is very familiar and important to respondents, that the overwhelming majority of CV responses appear to be of reasonable quality.

Another CV methods finding concerns the design of the payment card used on the tax bid WTP question (see the Appendix). The card presented four columns of numbers. Each column presented a linear progression of values. Column 1 increased from $0 to $50 by $10 increments. Column 2 increased from $75 to $200 in $25 increments. Column 3 increased from $300 to $1000 in $100 increments and column 4 increased from $2000 to $10,000 in $1,000 increments. This allowed a wide range to be covered without a large number of values listed on the card or starting bid problems, but does introduce a heteroskedastic measurement error into the process of selecting a value.

Respondents were asked to select a value on the payment card or give any other amount. Only two respondents provided values that were not listed. These values ($250, $1500) occurred between the last value of one column and the first value on the next column. Further, of the 68 respondents who gave nonzero bids, 40 (58 percent) gave values listed at the top or bottom of the column, with 31 of these (45 percent) giving values listed at the bottom of columns 1, 2 or 3. This seems to suggest that the value jumps between columns were too large (50 to 100 percent jumps) and that the reported maximum willingness to pa may have increased with smaller breaks between columns (i.e., adding values of $60, $250, $1,500, etc.). It also suggests that a paired logit analysis of the bids, such as used by Loehman and De (1982), may be an appropriate method for better estimating the WTP relationship.

Comparisons using the payment card approach and other bidding formats, reported in Cummings et al. (1984), have found the payment cards to yield substantially lower values relative to bidding procedures. In that light, it is again possible the bids reported here may be understatements of WTP.

Comparing COI and WPT Economic Measures of Health Damage

In this section we briefly address the ratio of WTP to COI measures from the perspective of the affected individual and the perspective of society based upon evidence in this study.

The rankings provide the first simple evidence that WTP measures will exceed COI measures for the affected individual. If changes in discomfort and leisure activity effects from changes in asthma are both ranked, and therefore valued, more highly than changes in medical costs, and changes in medical costs and work loss are ranked, and therefore valued, approximately equally, then the total WTP (the aggregate value of all damage categories) can be expected to be at least twice COI.

An alternative approach, again from the perspective of the affected individual, is to compare the total WTP tax bid for a 50 percent reduction in bad asthma days to estimated changes in medical costs for a 50 percent reduction in bad asthma days and, following the rankings, make the assumption that work loss equals medical costs for a change in asthma. This leads to a WTP/COI ratio of 1.61. This can be expected to understate the true ratio due to differences in the manner in which the COI and WTP values were estimated (Rowe and Chestnut, 1984). Other approaches to measuring the WTP/COI ratio examined in Rowe and Chestnut (1984) suggest that the ratio may be as high as 3.7, or that a COI measure may only be capturing 27 percent of total WTP for changes in asthma severity. If full medical costs or work loss costs are not included in the COI measure, which is frequently the case due to data limitations, a COI measure may be capturing an even smaller portion of total WTP.

Society incurs costs and may hold values for reductions in health incidences beyond those costs and benefits incurred by the individual. Society directly incurs the full medical costs including those paid by insurance or government programs, while the individual typically incurs less than the full medical costs associated with his illness. Further, society directly incurs lost work productivity when an individual is away from work whereas, due to paid sick leave, the individual may perceive minimal personal loss. Others in society may also hold values related to reduced sickness, and reduced effects of sickness for those who are affected. This is reflected in the research of Needleman (1976), where WTP by others to prevent an individual's death increased total WTP by 25 to 100 percent.

To obtain an estimate of the WTP/COI ratio from a social perspective, we take the individual WTP and COI values and escalate them by estimated social costs and benefits. On a sample wide basis, households directly pay about one half of variable medical costs while insurance or other programs paid the rest. Therefore the total social medical cost component of WTP and COI is approximately double that of the individual. This survey provides no information to gauge the social versus individual costs related to work loss. Therefore, for the sake of analysis and following the medical cost doubling, we assume total social work loss costs are double the individual's perceived work loss costs. In summary, the estimated social COI measure is calculated to be roughly double the individual's COI measure. Social WTP can also be expected to exceed individual WTP for other reasons. The estimated ratio WTP/COI for society is dependent upon the assumptions about the willingness to pay by others in society to reduce an individual's asthma, which we call Z. Using the above assumption on social incurred medical costs and work loss and assuming Z equals zero, the WTP/COI ratio ranges from 1.31 to 2.35. Assuming Z equals 50 percent of the individual's WTP, the social WTP/COI ratio increases to between 1.55 and 2.6.

The calculation of WTP/COI ratios undertaken here must be interpreted as suggestive due to measurement error and the assumptions used. With these caveats in mind, the analysis suggests that WTP measures for asthma are in the range of 1.5 to 3 times COI measures, as we have defined COI measures, using either the perspective of an individual or society. The difference is primarily due to substantial values held for activity effects and discomfort.

The results for WTP/COI ratios are for reductions in asthma severity and may not be representative of this ratio for other types of illnesses. We hypothesize that, due to differences in the magnitude of medical costs relative to income constraints and the likely magnitude of work loss, the ratio would be larger for minor health effects such as eye and throat irritation, and smaller for major illnesses such as angina or cancer.

Footnotes

1 Paper prepared for the American Economic Association/Association of Environmental and Resource Economists Joint Meetings, Dallas, Texas, December 27-30, 1984. This work was funded by the U.S. EPA Contract # 60-01-6543 and the California Air Resources Board Control # A2-118-32. We appreciate the assistance and input of Ann Fisher, Sylvia Champomier, Douglass Shaw, Don Waldman, Dane Westerdahl, Bart Ostro, Henry Gong, Anne Coulson, and John Dermond. Detailed research results can be found in Rowe and Chestnut (1984 a, b).

2 There may be a slight upward bias in the variable medical cost estimates. See Rowe and Chestnut (1984) for details on the calculation of medical costs.

3 In defense of the discussion leading to the second application of the consistency check with 25 percent medical costs, the average number of bad asthma days was 54 for those passing the check with 46 percent of medical costs, 27 for those passing with 25 percent of medical costs and 10 for those where neither application of the consistency check worked.

4 Of the four observations which were deleted, two had bids exceeding $1,000 but NBAD equal to or less than three and two had bids less than or equal to $50 but NBAD exceeding 75. In both cases, the bids were at least ten times larger or smaller than yearly variable medical costs.

5 The estimated change in medical cost for a 50 percent change in bad asthma days equals .92 (percent change in medical costs from a percent change in asthma, See Table 6) times .5 (50 percent change in asthma) x $272 (average variable medical costs), or $125. Assuming the workloss than e equals the change medical costs, (based upon the rankings), COI = $250. WTP/COI = $401/$250 = 1.61.

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APPENDIX

PART VII. OTHER

QUESTION 29. Please turn to the page titled Question 29. Here are some possible benefits you might receive from having your asthma improve. Please take your time and rank them from most important to least important. Exclude any that are of no importance.

	RANKING	CATEGORIES
Most important	______	a. Lower expenditure on doctors, hospitals, medicines, special equipment and services.
	______	b. Higher productivity at work or ability to get higher wages and salaries.
	______	c. More flexibility about where to live.
	______	d. Better chance to participate in desired leisure, recreation and social activities.
Least important	______	e. Less pain and suffering.

(SKIP QUESTION 30 IF STUDENT LIVING AT HOME)

QUESTION 30. a. Please turn to the page titled Question 30a. If federal, state, or local governments set up programs that could reduce pollens, dusts, air pollutants and other factors throughout this area that might reduce your (and your household's) Bad Asthma Days by half, but would cost you increased tax dollars, what would be the maximum increase in taxes each year that you and your household would be willing to pay and still support such a program? The list of dollar amounts is only to help you. Please feel free to select a listed amount or give any other amount.
______ $/Year.

(ASK 30b IF RESPONSE TO 30a WAS $0.0 OR RESPONDENT REFUSED TO CHOOSE ANY DOLLAR AMOUNT, OTHERWISE SKIP TO QUESTION 31).

b. Please turn to the page titled Question 30b. Which of the following reasons best explains your answer to the previous question #30a?

______ a. Having Bad Asthma Days half as often would not be worth any increase in taxes. (1)

______ b. Our taxes are already too high. (2)

______ c. I don't believe any such program could reduce my Bad Asthma Days by half. (3)

______ d. I should not have to pay for such programs; they should be undertaken by government and industry without any increase in taxes. (4)

______ e. Other (PLEASE SPECIFY) ______________________________ (5)
____